Scientific Discovery through Advanced Computing: Climate Change Prediction Program

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Multi-Resolution Climate Modeling

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Executive Summary

The purpose of this project is to create a global climate model with features that will provide the best available climate predictions, predictions that can be used effectively to assist in making useful decisions on issues related to climate on regional as well as global scales. It is rapidly becoming evident that regional climate events may be the predominant manifestations of global climate change, and that prediction on the regional scale is essential to the understanding of overall global change. Concurrent with the development of a model that has the capacity to predict climate "seamlessly" across various scales over the Earth, one must recognize the inherent variability of a model. This variability is only overcome by determining model climate predictions from statistics of a number of realizations of the model climate. Thus the model computations must be as rapid as possible, to provide those statistics in a practically useful time frame, given the time constraints large models put on limited computing facilities.

The method proposed herein for construction of the model is ideally suited to satisfy the requirements outlined above. By tiling the spherical domain with elements that can be sized arbitrarily to meet local scaling requirements (called spectral elements), the model can produce predictions on a range of scales over the entire global domain, allowing the necessary scale interactions without any user interference in the computational process. Moreover the method has the benefit of being able to take optimum advantage of parallel processing computers (the present state and future evolution of supercomputing) by minimizing communications amongst the elements and thus also amongst the computer processors since each element (contiguous group) is assigned to a processor. This procedure has already yielded dramatic speedup of the dynamics computations, potentially will similarly speed up the full general-circulation model (GCM), and makes the production of multiple realizations more feasible, combined with the probability that the method will also provide a more accurate prediction.

In addition to enabling useful climate scenarios on a variety of scales to include regional predictions for global change expectations and planning, the model will also serve as a research and training tool. Since many of the forces that drive the climate

system are not yet completely understood, the model can be used as an experimental environment to test various hypotheses on system forcing, especially in the area of spatially localized scale interactions. Knowledge gained in this process will help to refine the model, allowing it to produce improved predictions. As more students and scientists are introduced to the intricate features of the model, they will discover new and advanced details to further improve the model and pass their knowledge along to their colleagues and the next generation of modelers.